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Abstract

The MOSEL Reactor Concept
- A Relative Evaluation -

by

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The MOlten Salt Epithermal reactor concept (MOSEL) utilizes uranium and thorium fluorides dissolved in molten fluoride salts, and concerns a two-fluid, two-region reactor operating in the intermediate-to-fast neutron energy range. The concept involves a unique application of the molten salt technology developed in the USA during the past decade. Reactor operation is at low pressure (10 - 15 atmospheres) and high temperature (outlet coolant temperature of 650° C); the fluid nature of the core and blanket salts facilitates fuel movement and processing. The core fluid consists of UF_4 dissolved in NaF plus BeF_2 and is contained in tubes or plates of a high-nickel-containing alloy. Fuel fluid is circulated for purposes of mixing, fuel addition and removal, and to improve the effective thermal conductivity of the fuel salt. The core is internally cooled, with blanket fluid used as the core coolant. The blanket salt contains ThF_4 dissolved in NaF plus BeF_2. The core coolant transfers energy to the steam generator through an intermediate molten salt circuit. Fuel processing consists of uranium recovery by fuel fluorination, and is applied to both the blanket and core fluids. In the blanket cycle, uranium-free salt is returned to the blanket region, while the recovered UF_6 is reduced to UF_4 and fed to the core region. Core processing consists of uranium recovery and discard of fission-product-containing salt. The combination of blanket-salt recycle, low core-fuel volume, and processing limited to uranium recovery makes the fluoride volatility process

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uniquely applicable, and permits economic integration of the processing and reactor facilities leading to low unit processing costs (about $ 5/kg Th equivalent).

The fluid nature of the fuel, the simple processing scheme, the construction of the core without the presence of radioactive fuel, and the use of blanket fluid as the coolant permit reactor power to be increased without significant change in nuclear performance. This is done by extending the core in one direction, perpendicular to coolant flow, which also permits modular-type construction. The primary areas where further information is needed concern the energy variation of eta for U^{233}; the scattering and absorption cross sections of component salts and structural materials; the corrosion behaviour of fluoride salts as a function of temperature, salt composition and structural material; the effective thermal conductivity of various salts as a function of operating conditions; and the design of steam generators utilizing molten salts (salt melting temperature about 500° C). Nonetheless, based on present information, the MOSEL reactor concept can have economic breeding ratios in the range of 1.0 - 1.1, fuel cycle costs less than 1.5 mills/kwhe and power costs of 6 mills/kwhe in power plants of 500 Mwe rating, utilizing on-site processing and fuel recycle, and employing capital charges of 15 and 10 %/year for depreciating and non-depreciating items, respectively.

Relative to other reactor concepts having low power costs when very large nuclear power stations are considered, MOSEL systems appear to be economically competitive. At the same time, the MOSEL concepts appears superior for combining on-site fuel recycle, breeding ratios above unity, and low power costs in relatively small nuclear plants.